Make-believe.

I CAN well believe in Sally meaning a joke. Animals have a keen sense of "making believe" which is the essence of *play*. A child's first game is bo-peep—a make-believe. When a pair of friendly dogs have a jolly tussle, they make believe to engage in deadly combat.

A striking instance of this occurred to me some years back. I gave a dead mouse to a kitten. It was the first time she had seen one, and she sniffed at it inquisitively before deciding on tossing it about. A pair of slippers lay on the floor. She dropped it into one of them, and *immediately* proceeded to look for it most zealously in the other slipper, till I took up the first, which contained her booty; then she showed that it was no real lack of memory that had sent her on the bootless search.

The law allowed to game, when hunted for recreation, is perhaps the most marked evidence of the make-believe element which is to be found in the play of civilized adults.

Dublin, July 16. MARCUS M. HARTOG.

Dogs and Fire.

AN unrecorded type of the pluck of the fox-terrier was demonstrated to me recently. A young dog two or three years old, the property of Mr. Doyle, of Loretto Terrace, Bray, goes for fire with as much zeal as any of his race go for rats. When a newspaper thoroughly ablaze is thrown down, he stamps upon it with frequent short rushes till it is extinguished, and then worries the scorched remains before asking for a fresh opportunity. He gets excited and keen on being shown a crumpled newspaper or a match-box.

The possibility thus shown of educating dogs to tackle fire gives additional point to my friend Dr. Sigerson's published suggestion to use dogs as companions to night-watchmen, based on their keenness of scent. MARCUS M. HARTOG.

Dublin, July 16.

"The Theorem of the Bride."

REFERRING to the last paragraph of the review of my "Greek Geometry from Thales to Euclid" which appeared in NATURE of June 20 (p. 172) it may interest some of your readers to know that since the publication of my book I have found the expression—*τὸ τῆς νύμφης θεώρημα*—in the Scholia on the "Elements of Euclid." See "Euclidis Elementa," ed. Heiberg, vol. v. p. 217, Lipsiæ, 1888.

The expression seems to have been a common name of Euclid i. 47. GEORGE J. ALLMAN.

Belsito, Milford, Lymington, July 18.

RECENT RESEARCHES INTO THE ORIGIN AND AGE OF THE HIGHLANDS OF SCOTLAND AND THE WEST OF IRELAND.[1]

I.

THE records of geological history, like those of the human race, become more fragmentary and illegible, the farther back we trace them into the past. While the younger rocks of the earth's crust have been made to yield a more or less connected story of geographical and biological evolution, the oldest rocks have till comparatively lately been neglected, or have been tacitly left to mere speculation and conjecture. Only within the last few years have these ancient formations been seriously and sedulously attacked by scientific methods of inquiry. Though the progress of investigation has necessarily been slow, a steady advance in knowledge can be chronicled. There is a curious fascination in this department of geology. These venerable rocks reveal to us the oldest known part of the outer shell of our planet. The palimpsest of the earth's surface has been written over again and again during the long ages of geological history; but down among these bottom-rocks we reach the earliest recognizable inscriptions, and come as near towards the beginning of things as geological evidence by itself is ever likely to lead us. These records carry us back to a time anterior to that of the oldest fossiliferous formations, possibly to an epoch that preceded the appearance of vegetable or animal life on the globe. They reveal to us the very foundations of the earth's crust, on which all other known rocks rest, and out of the waste of which the greater part of these rocks has been formed.

Within the last ten years, after prolonged misconception and neglect, the most ancient rocks of the British Isles have come to occupy a foremost place among the researches of the geologists of this country. The tracts where they are now exposed to view, often among the wildest mountains, or "placed far amid the melancholy main," have become favourite geological hunting-grounds, and have furnished a notable amount of material for those disputes and combats which seem to form a necessary element in geological progress. Avoiding, as far as possible, matters of controversy, I propose this evening to offer a brief outline of the actual state of knowledge, up to the present time, of the history of those ancient crystalline masses of which our north-western mountains are composed.[1] The story is a somewhat involved and complicated one. But its main points may perhaps be conveniently grasped, if we bear in mind that they naturally group themselves into four sections: (1) the Archæan period; (2) the Cambrian period; (3) the Lower Silurian period; (4) the period of the younger Schists.

Let me at the outset remark that in the investigation of these early ages of geological history we enjoy in this country a special advantage. The British Isles stand on the oceanic border of a great continental region. They are therefore placed along that critical belt where not only have terrestrial disturbances been especially numerous and violent from the earliest geological times, but where an oscillation upward or downward of a few hundred feet has sufficed to make all the difference between land and sea. In the heart of a continent, as, for example, over the vast plains of Russia, long cycles of geological time have passed without serious disturbance of any kind. To this day some of the ancient Palæozoic sediments in that region, for hundreds of square miles in extent, lie as level as when they were deposited on the sea-floor. They have been uplifted bodily into land, but still remain little more than mere hardened mud and sand. In Western Europe, on the other hand, where from the remotest geological antiquity the oscillations and dislocations have been innumerable, every successive continental uplift has recorded itself in some crumbling or fracture of the rocks. Hence in the geological map of that region the various formations form a pattern of exceeding complexity, while in the maps of Eastern Europe each of them covers a broad unbroken expanse.

I.—*The Archæan Period.*

The oldest known rocks of Europe, now generally termed Archæan, are well exposed along the north-western borders of the continental area from the extreme north of Scandinavia, by the west coast of Scotland, to Galway Bay in the west of Ireland, a total distance of some 1600 miles. They give rise to topographical features which, where fully developed, strongly distinguish them from all younger formations. Nowhere else can such extraordinary unevenness of surface be found. Knobs, hummocks, and ridges of bare or almost bare rock, separated by narrow gullies or by wider winding valleys, roughen the ground in every direction. In the hollows lie innumerable tarns and lakes, or flat tracts of bog where lakes once were. In some districts, indeed, there is as much water as land in a given number of square miles. On a large scale, this type of scenery is perhaps best displayed in Finland; on a small scale, it is repeated all through the chain of the outer Hebrides, as well as on the Archæan areas of the mainland. The most southerly points in Scotland where it can be recognized are the Island of Iona and the Ross of Mull. It reappears, however, far to the south in Ireland; standing out in the bold cliffs from Erris Head to Achill Island in the west of Mayo, and finally covering an area of more than 500 square miles in South-Western Galway. In this last-named district, as Prof. Hull has shown, so completely are the scenic features of the north-west of Scotland reproduced, down even to the minutest details, that the geologist, even before he stands on the rocks, has no difficulty in deciding that they can only be Archæan.

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[1] The Friday evening lecture delivered at the Royal Institution on June 7, by Dr. Archibald Geikie, F.R.S.

[1] It would be obviously out of place to include here references to the voluminous literature of the subject. A condensed summary will be found in the Report by the officers of the Geological Survey, Quart. Journ. Geol. Soc., vol. xliv., 1888.

What, then, are these most ancient rocks of North-Western Europe, and what has been their history? Unfortunately, the answer to these questions cannot be succinctly and definitely given. Owing to the antiquity of the masses, and the prolonged series of geological revolutions which they have undergone, their original characters have been somewhat effaced. In those areas where they have been least altered, and where, therefore, they approach nearest to their primitive structure, they have been found by my colleagues of the Geological Survey to be crystalline rocks, such as gabbros, diorites, and other highly basic compounds. These occur in zones or bosses surrounded by and passing into rocks which have acquired the peculiarly banded structure characteristic of gneiss. That these various rocks were eruptive—that is, that they originally formed portions of igneous material that rose in a molten or plastic condition from below—can hardly be doubted. They remind us of the deep-seated portions of some of the eruptive bosses so abundantly intruded into the crust of the earth, and now so plentifully exposed at the surface after prolonged denudation. Like these, they show a rudely striped or banded arrangement suggestive of the planes of movement or flow-structure seen in consolidated igneous material. They have probably resulted from successive protrusions of eruptive rocks at some depth within the crust of the earth.

Nowhere, however, in the region to which I am referring, has any trace of superficial eruption yet been detected. There are no true volcanic ejections, nor any evidence that the rocks, though certainly of eruptive origin, were ever connected with the ordinary explosive operations of volcanic vents. Not only so, but after the most careful search from Sutherland to Galway not a vestige have we yet found of any unquestionable sedimentary material. There are no conglomerates, no sandstones, no shales; nor even any materials that might be supposed to represent these in a metamorphosed condition. Of the actual surface of the earth these Archæan rocks afford no recognizable trace. They obviously did not form the superficial layer themselves. They must have lain deep under a cover of other material, under which they acquired their crystalline structure, and by the subsequent removal of which they have been exposed to the light.

One of the most impressive features of our recent researches among these rocks is the evidence of the magnitude of the interval of time between their original protrusion and the formation of the next group of rocks overlying them. Of the many breaks in the geological record, none is more complete than this. We pass at one step from Archæan rocks, dating no doubt from an early stage in the consolidation of the crust of the planet, to the gravelly and sandy deposits of an inland sea, which already present all the familiar characters of the sedimentary accumulations of later geological time.

Some of the more prominent events in this protracted interval may be more or less clearly discerned; others can only be dimly conjectured. Arranging in chronological order the more important which have lately been recognized by the Geological Survey, I would direct your attention to four main episodes in the Archæan history of our North-Western Highlands.[1]

In the first place, the crust of the earth over that region was thrown into a series of low arches or folds, the axes of which ran in a general north-east and south-west direction. Its component rocks were crushed and sheared, so as to acquire the banded and crumpled structure of typical gneiss. Perhaps we may trace to these primæval terrestrial movements the first shaping of the European continent, which certainly has grown from north to south. At all events, it is interesting to note that the undulations into which the rocks were thrown took that north-easterly trend which is still so marked in the long belt of crystalline schists from the North Cape all the way to the west of Ireland.

In the second place, after these early disturbances, and probably long after them, a remarkable series of manifestations of plutonic energy occurred. The region extending from the north-west of Scotland to the west of Ireland was convulsed by the production of innumerable dislocations in the solid terrestrial crust, having a general west-north-west direction. Up these gaping rents, molten basic lava rose from some subterranean reservoir, and solidified in broad dykes of black basalt. Some of these dykes can be traced for ten or twelve miles, till they run out to sea at the one end and pass under younger overlying formations at the other. Yet again, at a somewhat later period, another series of fissures was opened slightly oblique to the direction of the first; and, in these, still more basic lava formed a second series of dykes trending nearly east and west. Nor was this all, for there followed a third period of convulsion, which gave birth to a series of huge dykes of granite.

Whether or not any of the eruptive material that filled these successive fissures ever rose to the surface and flowed out there, or gave rise to the explosive phenomena of true volcanic vents, cannot be certainly affirmed. But an interesting piece of evidence points to the probability that such a connection with the surface was really established. In some of the conglomerates of the next succeeding group (Cambrian or Torridon sandstones), there occur fragments of highly vesicular lavas, which show that at some time previous to the deposit of these coarse sediments, active volcanic vents existed somewhere in the region of the north-west of Scotland. As yet, however, no trace has been discovered of any of the lava streams which flowed out at the surface.

Although volcanic energy has long been quiescent over the British Isles, probably no area in Europe exhibits within so limited a space so long and varied a record of volcanic eruptions. There is, therefore, a peculiar interest about these traces of the ancient volcanoes which in Archæan time rose along the Atlantic border in the north-west of Scotland, for they stand at the very beginning of that long history. Moreover, so far as we can interpret their remains, they seem in a curious way to have anticipated the characteristics of the last great volcanic episode in Britain—that to which we owe the Tertiary basaltic plateaux of Antrim and the Inner Hebrides. In both cases the distinguishing feature was the fissuring of the terrestrial crust and the uprise of basic lava in the rents, with the consequent production of innumerable parallel dykes trending in a general north-westerly direction.

In the third place, after the production of the basic dykes, there came another prolonged interval, during which a series of remarkable terrestrial disturbances affected the north-west of Scotland. The crust of the earth in that part of Europe was once more dislocated by innumerable fissures, produced probably at successive epochs of paroxysm, for they can be grouped into three distinct series. Of these, one runs approximately parallel with the north-west dykes, the second trends east and west, and the third runs north-east and south-west, or north and south. So far as yet discovered, no lava of any kind welled upwards into these fissures. They are ruptures, but not dykes. They were accompanied, however, by the manifestation of another form of terrestrial energy, the geological efficacy of which has only recently been recognized. The lines of vertical fracture became also lines of horizontal or oblique movement during the vast strain of terrestrial contraction. One side was driven past the other side, and with such irresistible force that the rocks for some distance on either side were dragged into the line of movement, crushed down, and forced to assume a new crystalline arrangement of their materials. The basalt dykes, reduced sometimes from a width of 50 or 60 yards to only 4 feet or less, were changed into diorites, and where the shearing was greatest, into hornblende-schists. The gneiss, in like manner, was thrown into sharp folds, and had a newer foliation developed in it parallel with the new planes of movement.

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[1] Those who wish fuller details on this subject will find them in the Survey Report already quoted.

In the fourth place, during the prolonged succession of changes which I have thus briefly summarized, there must have been in progress a continuous denudation of the surface of the Archæan land in the north-west of Europe. Doubtless, each of the subterranean disturbances more or less affected the surface. The land was by degrees ridged up above the sea, and its height and breadth were probably from time to time increased by local uplifts accompanying the disturbances. But as soon as the land appeared, it began to be attacked by the waves, the air, rain, and running water. Terrestrial convulsions were intermittent, but superficial waste continued uninterrupted. Whatever may have been the character of its topography, the first formed land, as soon as it rose, became a prey to the denuding forces, and had its original surface gradually stripped off. We have no means of telling how great a thickness of material was in this manner removed from the land before the time of the next geological period, nor for how vast a time this slow process of denudation went on. All that we can now discover is a series of detached fragments of the surface of this primæval Europe, which have been preserved by being buried under the pile of material formed out of the waste of the Archæan rocks. From these fragments we learn that the rocks had been enormously denuded so as to lay bare to the surface some of their deep-seated parts, the land shaped out of them having been carved into dome-shaped hills and basin-like hollows, not very different from those which are so characteristic of the Archæan tracts to-day.

II.—*The Cambrian Period.*

We now reach the base of the stratified formations of the British Isles, and enter upon a series of records which deal not with subterranean but with superficial changes, and in which the earliest geographical conditions of our area are more or less fully chronicled. These records consist of a pile of dull-red sandstones, conglomerates, and breccias, with grey, green, and black mudstones, marls, and shales, attaining a maximum thickness of perhaps 10,000 feet. This great accumulation, chiefly of coarse sediment, was derived from the waste of the Archæan land. The pebbles in its conglomerates are fragments of that land, and enable us to form some conjecture as to the nature of the materials that composed its surface. An examination of these pebbles brings to light the important fact that besides the detritus of the gneiss and other Archæan rocks which can now be seen *in situ*, the conglomerates are made up of materials derived from some still older sedimentary formations which have entirely disappeared from our area. These included such rocks as quartzite, greywacke, shale, and limestone, besides abundant pieces from the lavas, which I have already referred to as having probably been erupted to the surface in pre-Cambrian time. The destruction of these intervening deposits, and the chance discovery that they once existed because fragments of them have been found in later conglomerates, serve to impress upon us the imperfection of the geological record, and the vastness of the intervals of time which may sometimes separate two successive groups of rock.

The thick mass of red sandstone and conglomerate which rests directly on the Archæan gneiss forms some of the most singular scenery in the north-west of Scotland. Owing to vast denudation, which began before the next group of strata was deposited, it has been worn down into isolated mountains, which rise like a chain of colossal pyramids along the western shores of Sutherland and Ross. The almost level lines of stratification give to these eminences a look of architectural symmetry, in striking contrast with the more tumultuous aspect of the other rocks of the region, while their red tone of colour marks them out boldly from the wastes of grey gneiss below and the crags of white quartzite beyond. From the far northern cliffs of Sutherland these massive red sandstones can be followed almost continuously to the southern headlands of Skye. They reappear in great force in the Island of Rum, beyond which they are not certainly traceable. A group of highly altered grits and schists, seen under the great basaltic plateau of Gribun, on the west side of the Island of Mull, may mark their extreme southerly limits.[1] The red sandstones certainly do not come so far south as Iona, and not a trace of them has been met with in Ireland. They extend westwards across the Minch, for a small portion of them skirts the eastern shore of the Long Island. How far they may have stretched eastward cannot now be determined, for their limits in that direction have been obscured or effaced by the extraordinary series of gigantic earth-movements to be afterwards referred to. There can be little doubt, however, that they did not reach the district east of the line of the Great Glen, though they not improbably lay in thick mass over much of the country to the west of that valley.

We cannot now trace the original limits of these red rocks, yet we can hardly doubt that they never covered an area at all comparable in extent to that of the rocks below and above them. They appear, indeed, to have been accumulated in one or more basins, shut off from free communication with the open sea, where the deposition of ferruginous precipitates among the ordinary mechanical sediment could go on during the deposition of many thousand feet of rock. Such conditions of sedimentation were not very favourable to the existence of life in the waters of these inclosed basins. Nevertheless, that the waters were not entirely lifeless is shown by the discovery of organic remains on two widely separated horizons among the sandstones. These remains occur in grey and dark shales, the colour and composition of which suggest a temporary influx of water from without, and the cessation for a time of the deposition of the iron-oxide. At the lower horizon the fossils consist of calcareous rods, the organic grade of which is still in dispute; at the higher they include some doubtful impressions and the casts of worms. The fossiliferous bands are to be more thoroughly searched this summer, and it is hoped that something more determinable may be obtained from them.

Nevertheless, indistinct though these relics undoubtedly are, they may claim the interest which arises from their being at present the very oldest traces of organized existence yet found within our islands. Murchison classed the red sandstones of Western Sutherland and Ross as "Cambrian," inasmuch as he found them to underlie unconformably strata containing what he believed to be Lower Silurian fossils. It is not improbable, however, that they belong to an older time than any of the Cambrian rocks of Wales.

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[1] My attention was called to these rocks by the Duke of Argyll, who himself suggested their possible Cambrian age. I visited them this spring, and found them to be greatly metamorphosed. They do not appear in Iona, where the base of the sedimentary series is found resting on the Archæan gneiss.

That the red sandstones of the north-west of Scotland were laid down in shallow water seems to be clearly indicated by their current-bedding and ripple-marks, as well as by the occurrence of bands of conglomerate among them on many successive horizons. Yet they retain these characters throughout a depth of some 10,000 feet. We can walk over their edges and count every successive stratum for a thickness of more than 3000 feet along the sides of a single mountain. How, then, could such a continuous mass of shallow-water deposits be accumulated? I am not sure that any wholly satisfactory answer can be given to this question, which is one that arises in the investigation of various epochs of geological history. That the basins must have been due to local subsidence can hardly be doubted. We may suppose that this downward movement continued at the same time that the ridges which bounded the hollows continued to be forced upward. New shore-lines would thus be brought to the level of the water, and coarse shingle might be swept down upon previously deposited fine sediment. If occasionally the barrier between the basins and the open sea were partially submerged, the muddy ferruginous water of the inclosed tracts might be cleared out, and the denizens of the sea might for a time enter them. Possibly the grey and dark shales may mark these irruptions of the ocean.

That similar conditions of geography prevailed at that period in the extreme north-west of Europe is indicated by the fact that in Norway a group of red sandstones and conglomerates, known as the "sparagmite rocks," is interposed between the Archæan gneiss and the oldest of the fossiliferous formations. In these Scandinavian rocks we probably see traces of the extension of similar inclosed water-basins along the eastern border of the primæval Atlantic Ocean northwards among the hollows of the Archæan land.

Before the next great geological period these basins had been entirely effaced, and the geography of the region had wholly changed. This transformation is probably traceable to two causes. First, the terrestrial movements which led to the formation and continuance of the basins may in the end have caused their extinction by raising them into land, and possibly at the same time by folding and fissuring their accumulated deposits. Secondly, as soon as these deposits, whether split open or not, were exposed to the atmosphere they would begin to be worn down. That erosion took place during a prolonged period, and to a vast extent, is shown by the fact that in some places the thick cake of sandstone was hollowed out down to the Archæan platform below it before the next succeeding formations were deposited. Here again we are presented with a striking example of the imperfection of the geological record.

(*To be continued.*)

THE PRIVATE LABORATORY OF MARINE ZOOLOGY AT RAPALLO.

THIS very modest zoological station does not in the least pretend to compete with the splendid ones of Naples, Plymouth, Roscoff, Banyuls, &c. Considerable sums are needed to build and keep up such establishments, so that their numbers will necessarily be always very limited.

We have thought that with relatively little expense it might be possible for zoologists to procure in great part the advantages that these larger stations offer, and to concur in their action, by establishing a certain number of small stations on favourable spots of the Italian coast. Our idea is to have dependencies of the zoological laboratories of the nearest Universities, almost as if parts of those laboratories were transported to the sea-shore. The cost of these stations would not be very great. All that is strictly necessary is a room with good light, and as near as possible to the sea, provided with small aquariums, with the usual pump, with fishing apparatus, and the ordinary furniture of every laboratory, except microscopes and other costly instruments, which every investigator would bring with him. The books also might be reduced to the treatises and the "Faunæ" ordinarily used. It is indispensable that the station should possess at least one boat for short excursions: for deep dredging, and for longer excursions that are less often made, the necessary vessels could be hired.

By these modest means notable results might be obtained. Almost all anatomical and histological researches would be possible, the inquirer either making them entirely on the spot, or limiting his work to the first observations that ought to be made on specimens freshly caught, and preparing the materials for later and more leisurely study.

Stations of this sort already exist abroad, such as the laboratory of marine zoology of Wimereux, the Netherlands movable station, the station of Misaki in Japan, &c.

In Italy, Prof. Kleinenberg proposed to found a station of this kind at Messina, but of greater proportions, hoping that it might serve principally as a school for beginners; but unfortunately his idea has not yet been realized. Neither has anything come of the project of Count Alessandro Ninni to establish a station at Venice that might serve at the same time for purely scientific researches, and for practical studies on the industrial cultivation of sea animals.

Convinced of the utility of small stations, we have made an experiment in forming one which we will now describe.

Unwilling to go too far from Turin, we have chosen the little town of Rapallo on the Eastern Riviera, near Genoa. It is situated at the end of the gulf of the same name, is one hour's distance by boat from Portofino, that marks the extremity of the gulf towards Genoa. The Gulf of Rapallo is pretty well sheltered from the winds; the shores are rather rocky, and vegetable and animal life is very various and abundant. It also presents notable variations of depth. From Rapallo to the extremity of the gulf, a distance of 4 kilometres, the depth gradually reaches 90 metres, and at a like distance in the open sea of Portofino, the depth is more than 400 metres. The movement in the haven is limited, and hence the waters even near the town are clear. As to the town, it is beautifully situated, and the neighbouring places are various and very pleasant. It is also a very quiet town, where the greatest liberty can be enjoyed.

Our station occupies a space of a hundred square metres, and it is placed a few metres from the sea, on the ground where the docks formerly stood. In this space, inclosed by a wooden palisade, is the little building which looks like a *chalet*, the lower part in brick-work, with wooden walls and a roof covered with zinc. The edifice consists of only one large room, 7 metres in length, and 4·50 in width (inside). The height up to the wooden ceiling, that is under the roof, is about 4 metres. One of the longer walls is turned to the north. A window, consisting of nine large divisions, runs the whole length of this wall; and against this wall is placed the working-table, which also occupies the whole length; at it six persons can work. The door is on the shorter side that looks on the sea; over the door is placed the reservoir of sea-water capable of containing more than 800 litres; it is filled by a small rotatory pump. By means of pipes the water is brought from this reservoir into the aquariums that are placed in the middle of the